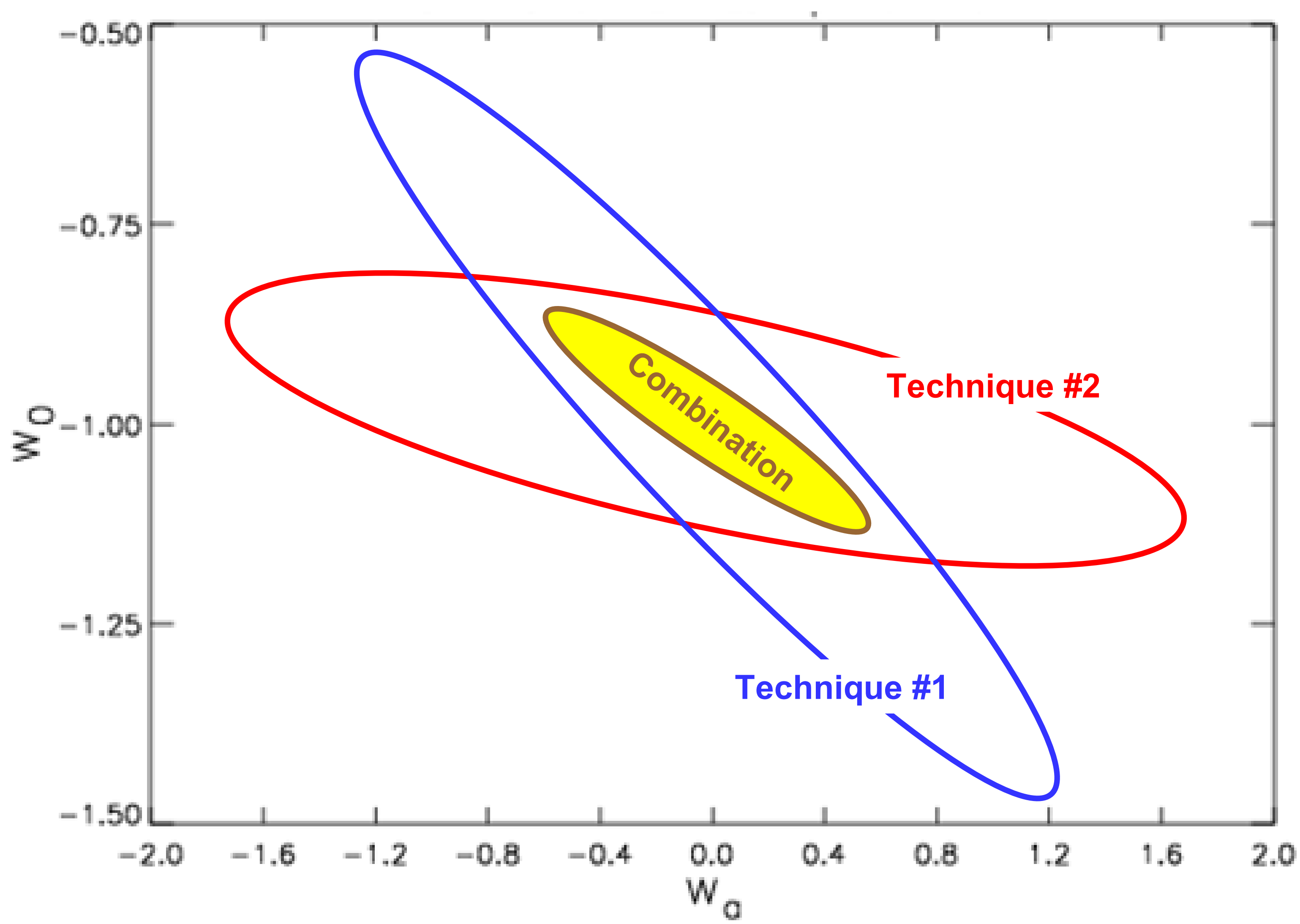
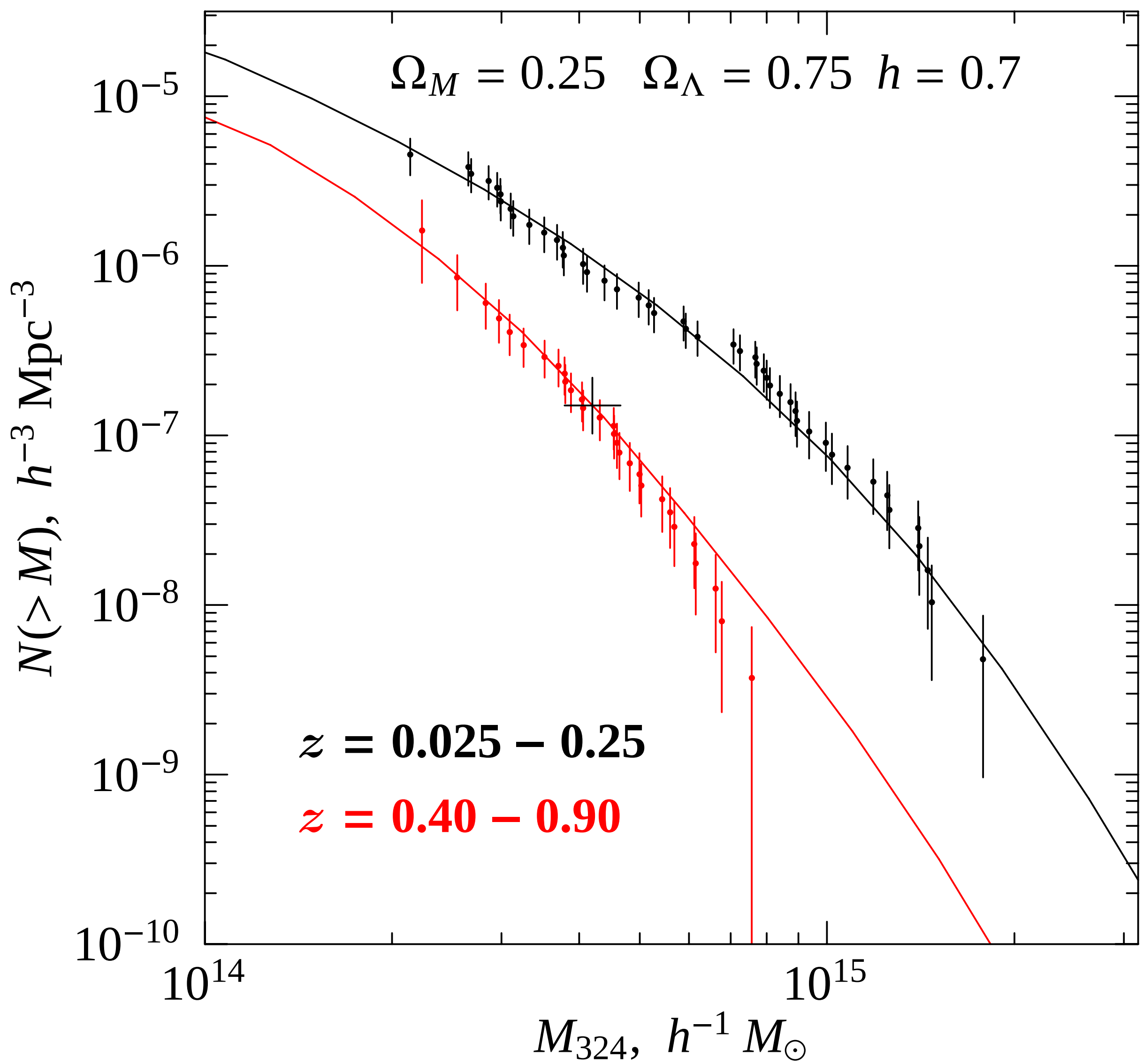
Contribution of Con-X to Growth of Structure Test with Cluster Surveys

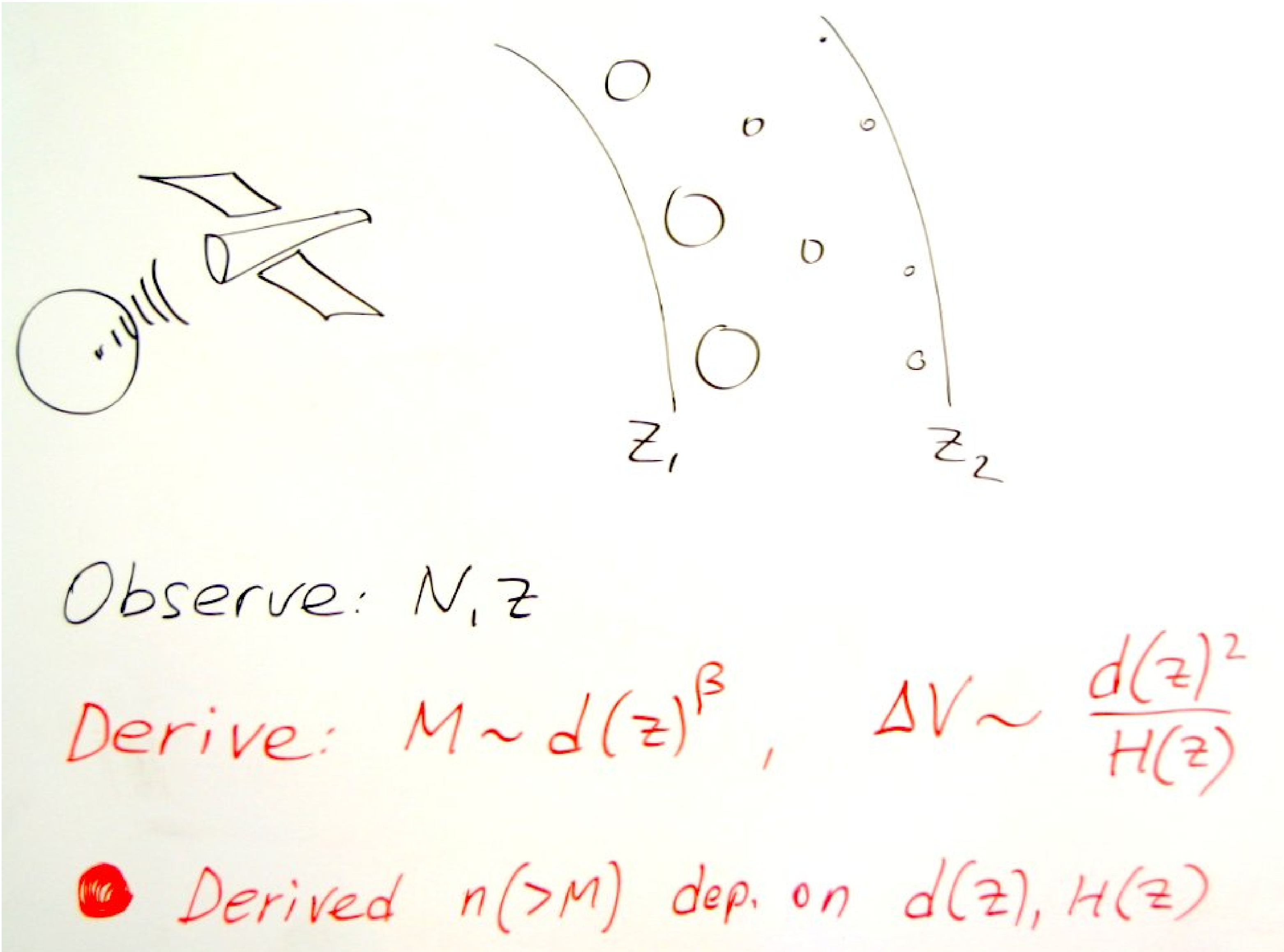
Dark Energy Observables



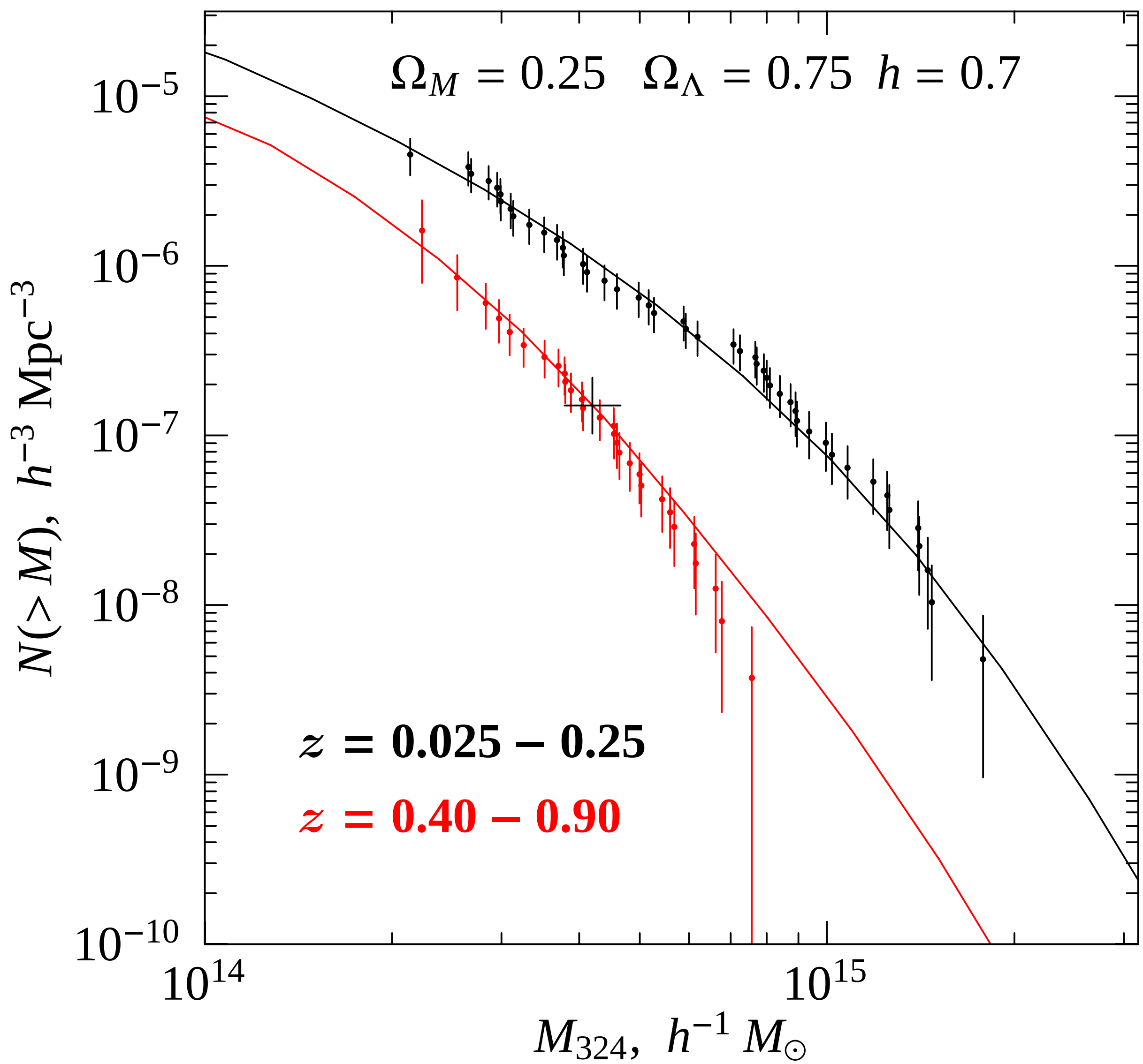
Cluster mass function as DE probe



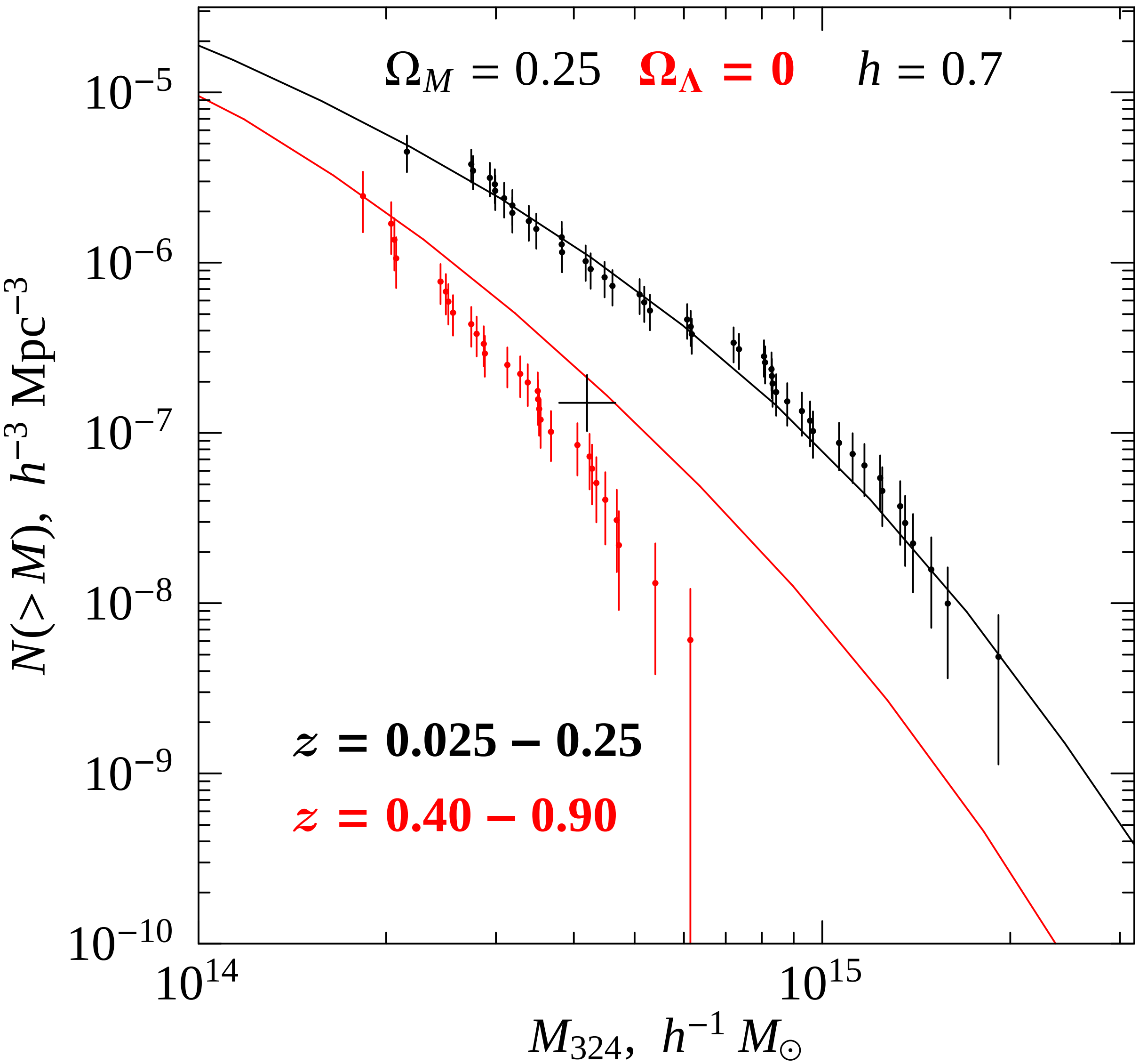
Role of $d(z)$ and $H(z)$



Cluster mass function as DE probe



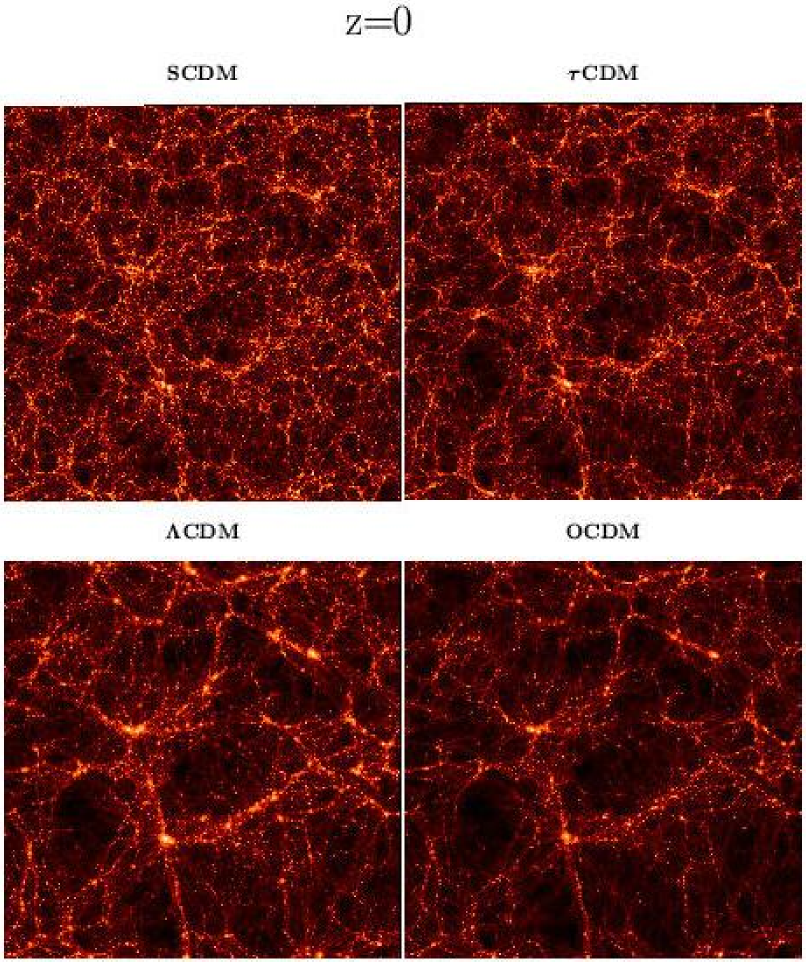
Also detect Λ

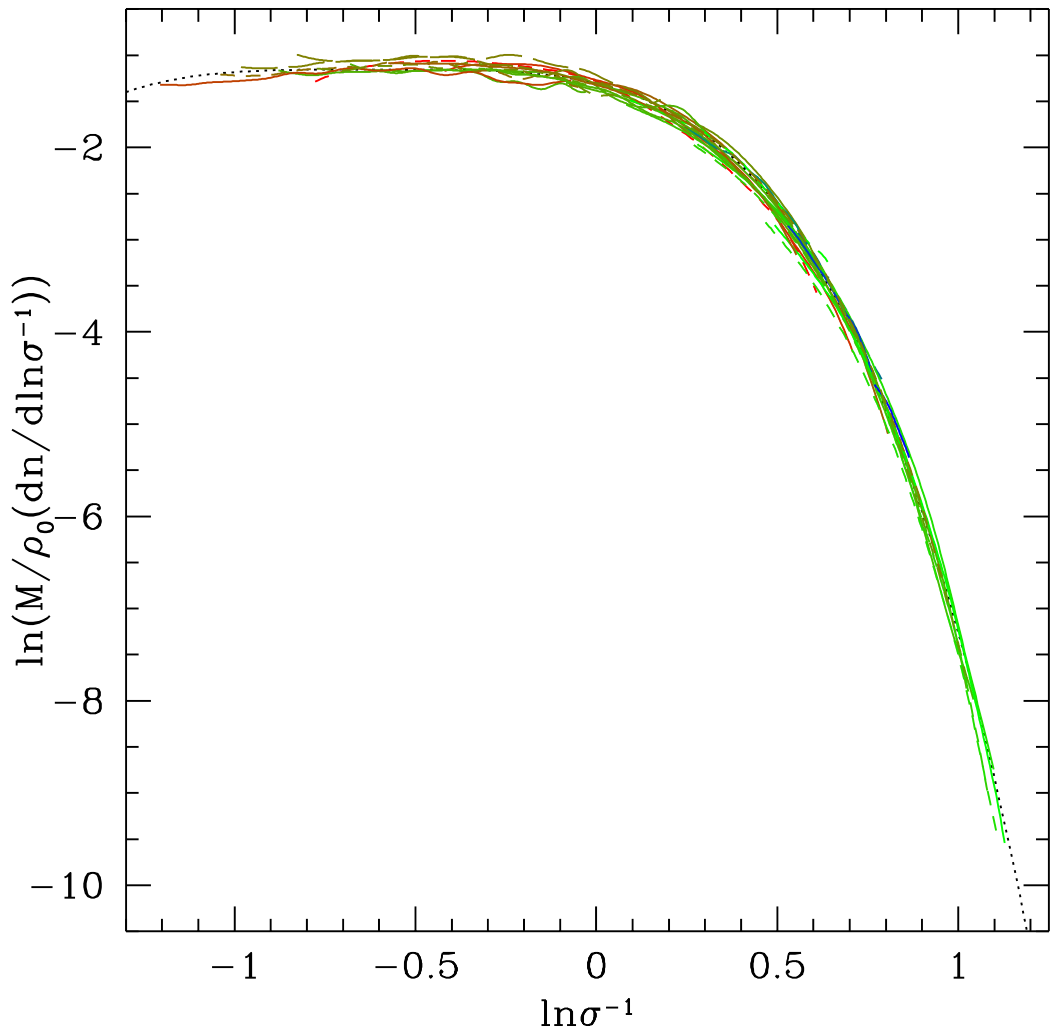


α π ο λ ο γ ί α

	Supernovae Ia	Clusters	
1	$M_{\text{progenitor}} = 1.4 M_\odot$	$F = G \dfrac{m_1 m_2}{r^2}$	100 %
2	empirical relation $L - \mu(t)$ − colors	classical gasdynamics	20 %
3	evolution with z?	non-gravitational effects	5 %
4	Straightforward observable	SO WHAT?	
5	“purely geometric test”		

Dark matter only simulations

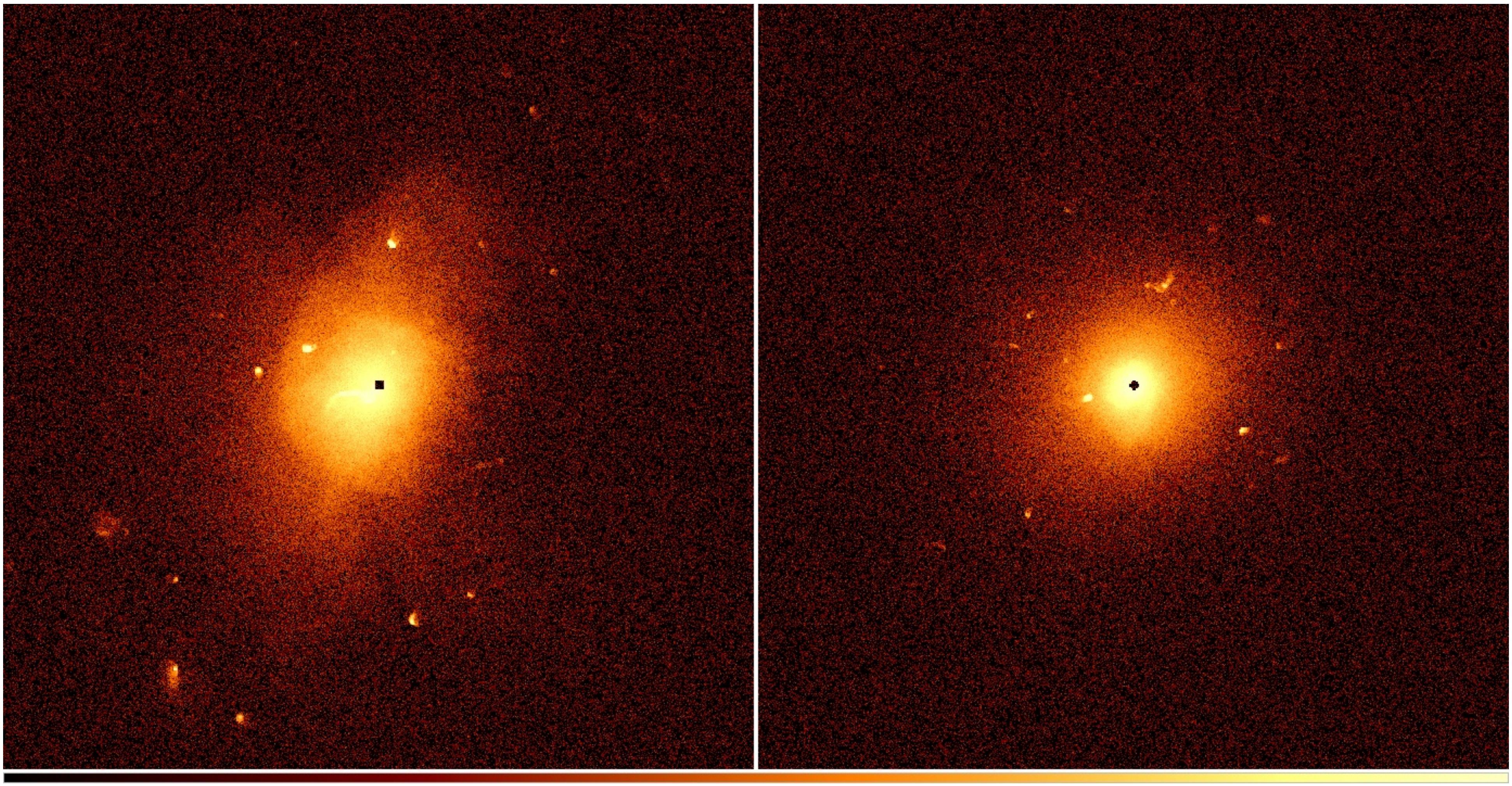




VIRGO simulations

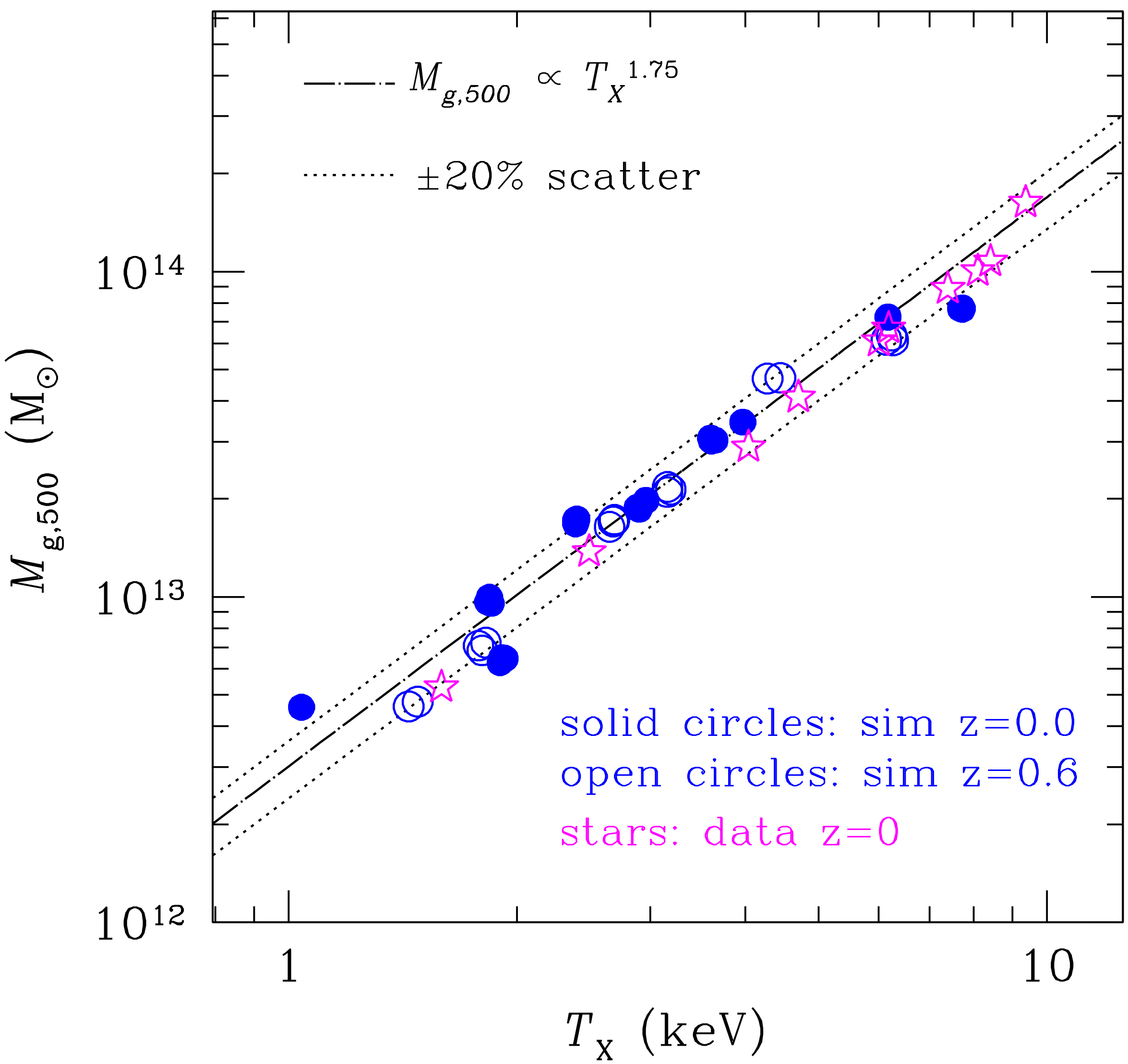
Jenkins etal '01

High-resolution hydro-simulations



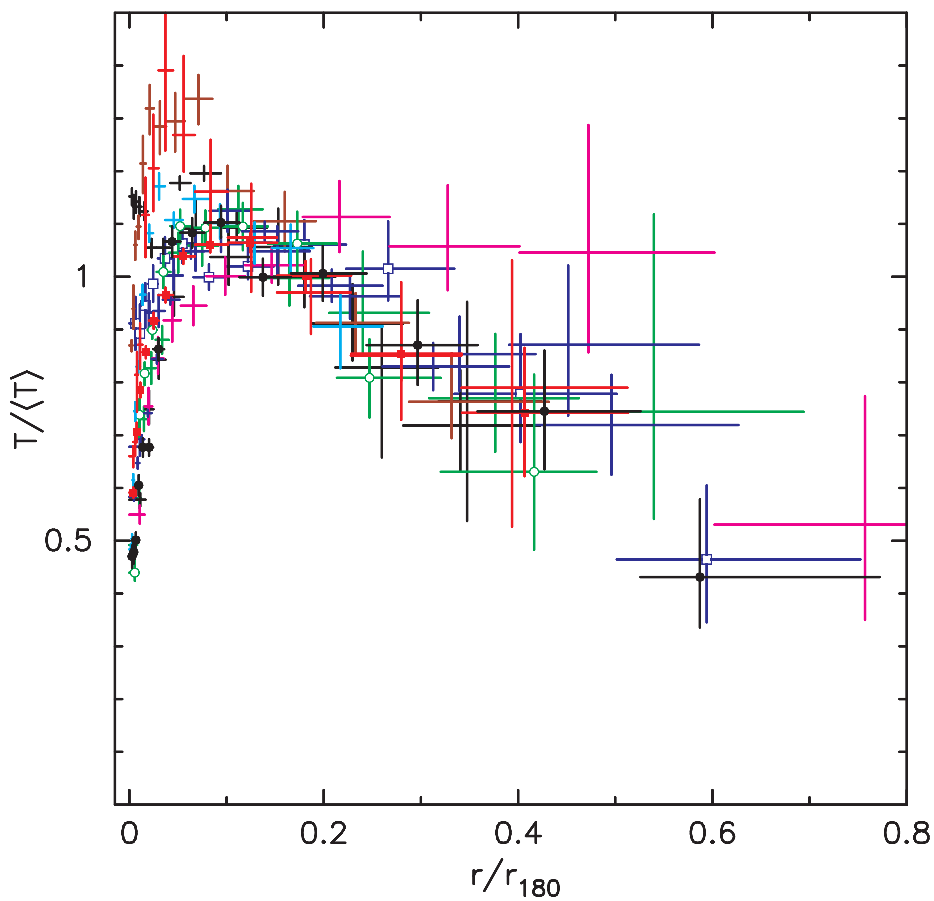
Nagai, Kravtsov, Vikhlinin (NKV)

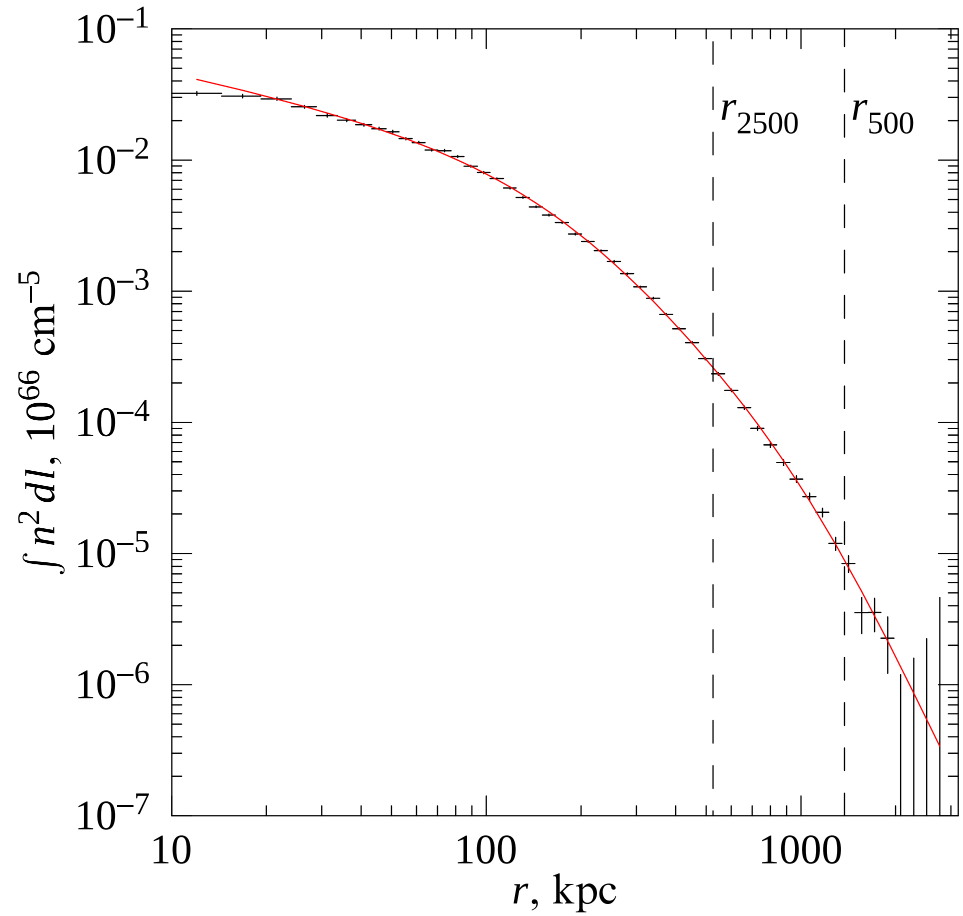
Simulations with cooling and star formation



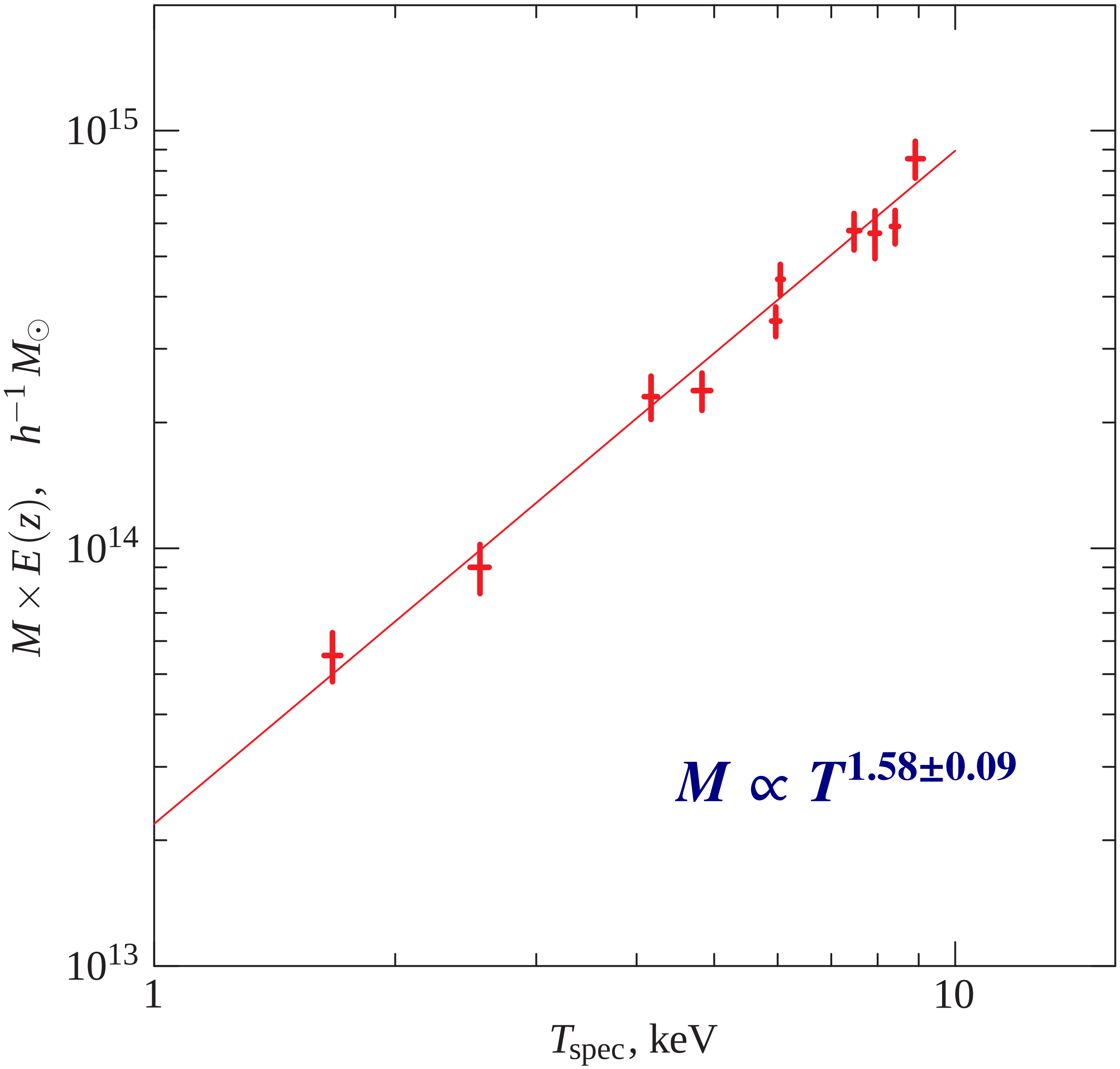
KVN '06

Chandra data: profiles





Chandra data: $M - T$ relation



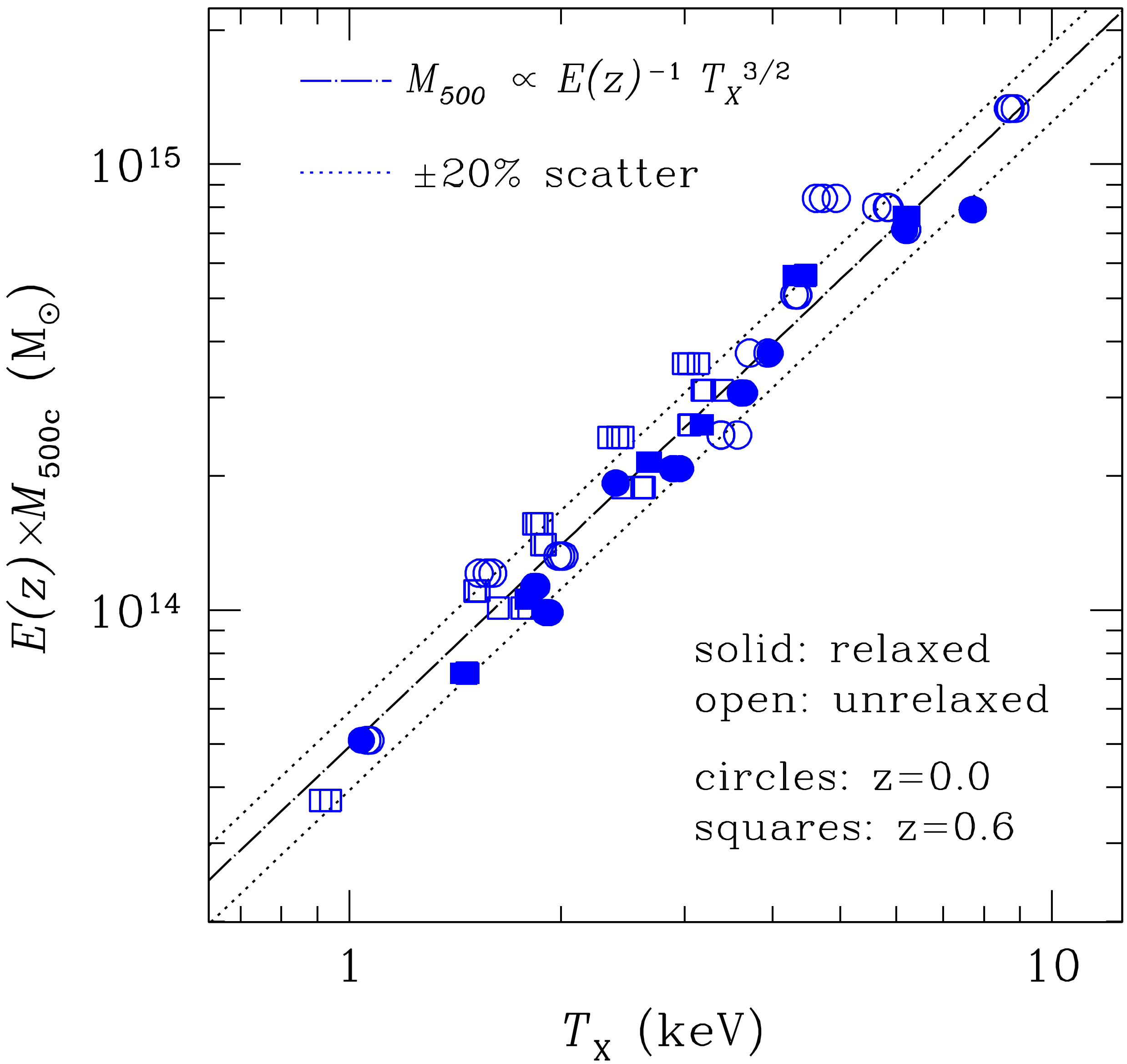
Approach to mass estimates

1. **Use *robust* results from simulations to find good proxy for M_{tot}**
   - **accurate (low-scatter)**
   - **evolves as predicted in self-similar theory**
   - **insensitive to dynamical state**

2. **Calibrate $M - X$ with relaxed clusters (or weak lensing)**

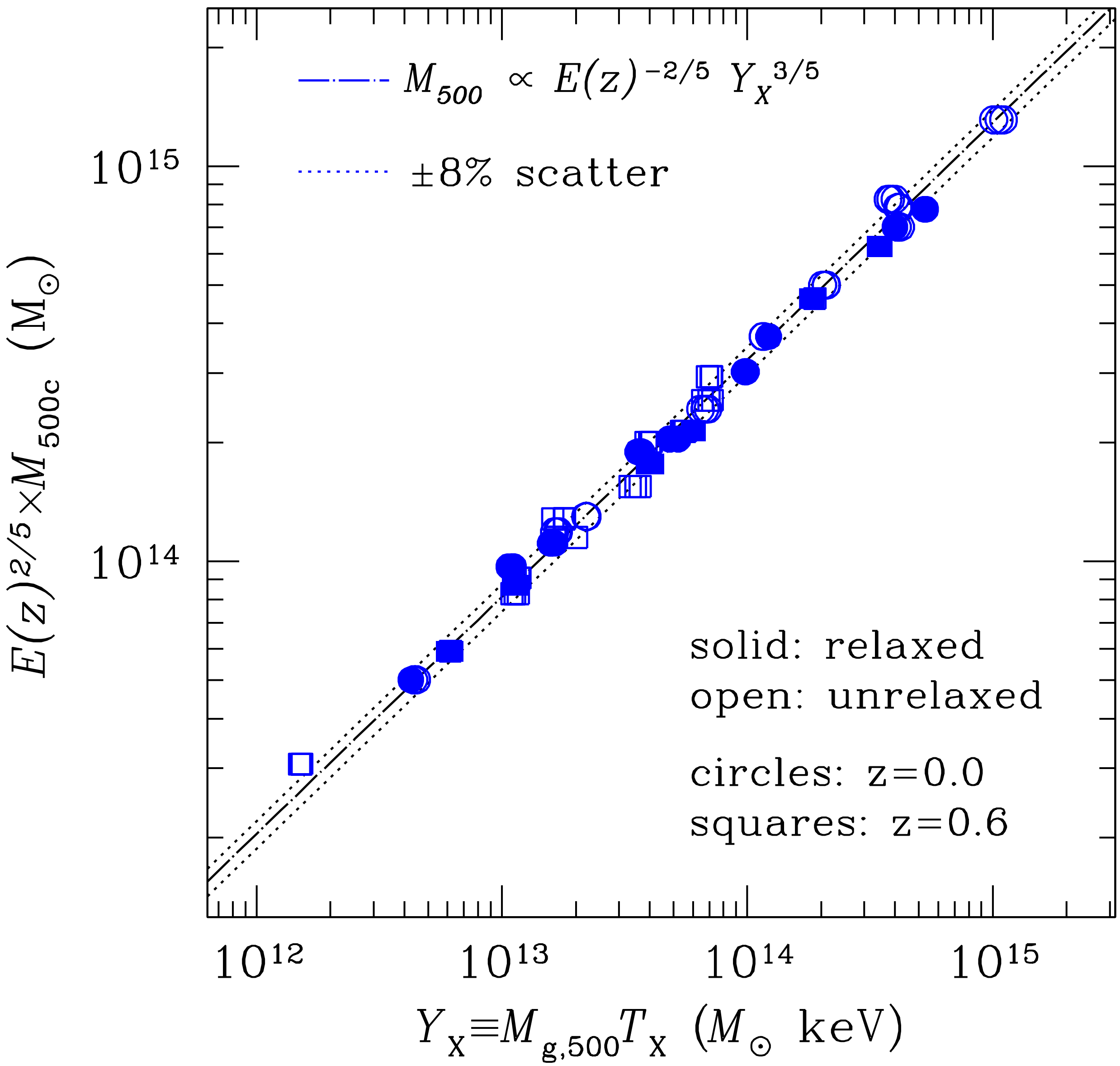
3. **POSSIBLY, use first-order corrections to normalization and evolution of $M - X$**

comparison of mass proxies: T_X–M



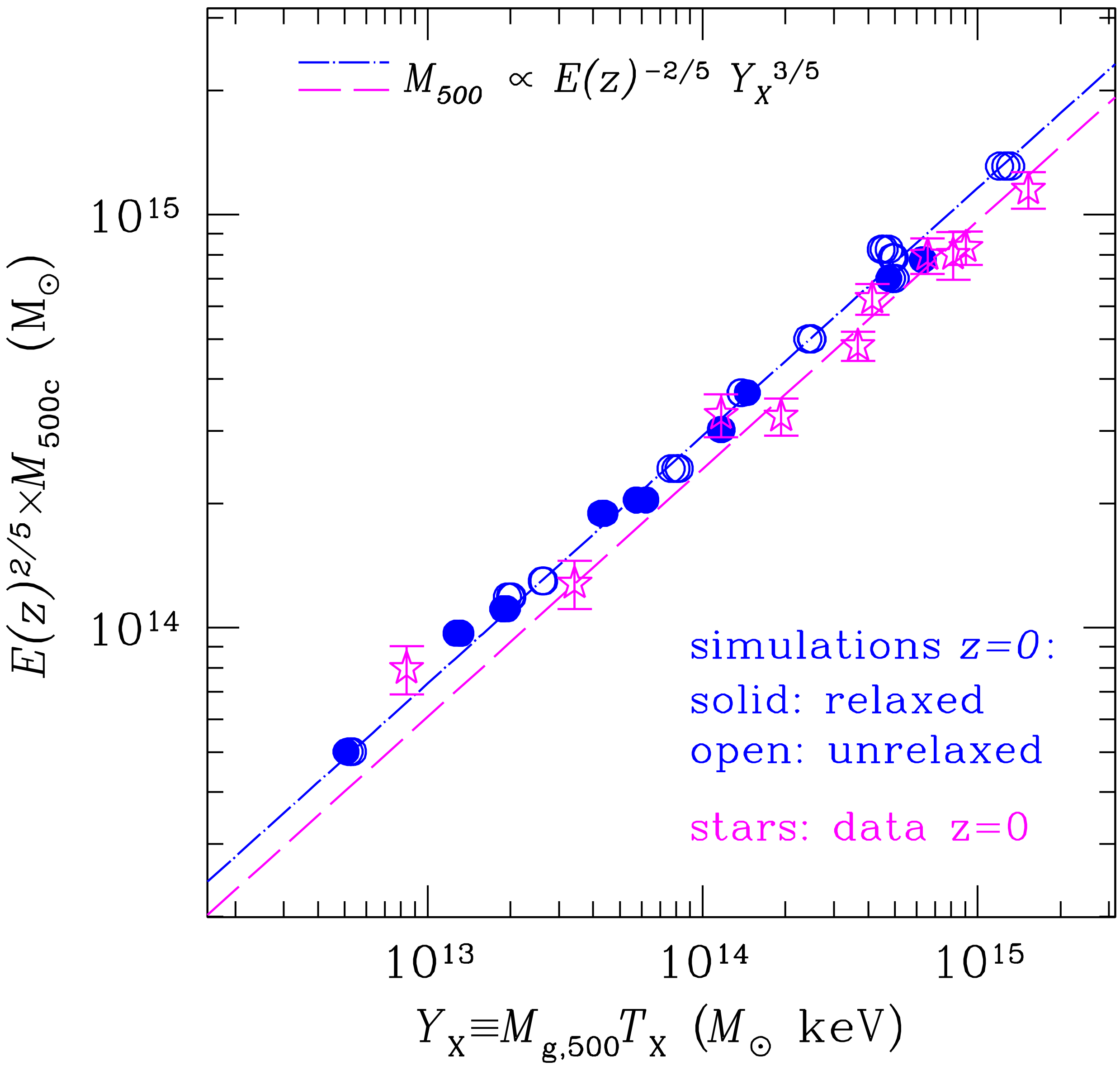
KVN '06

comparison of mass proxies: Y_X–M



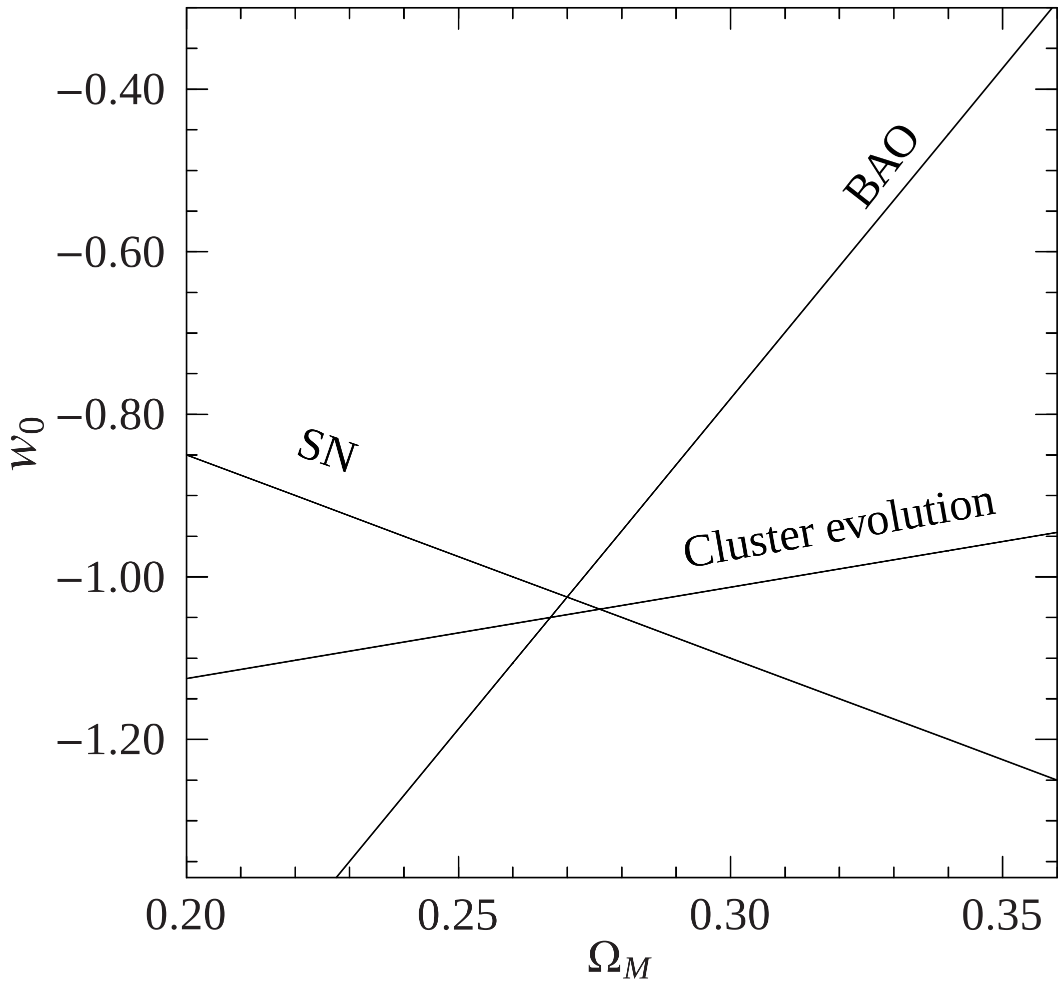
KVN '06

comparison of mass proxies: Y_X–M



KVN '06

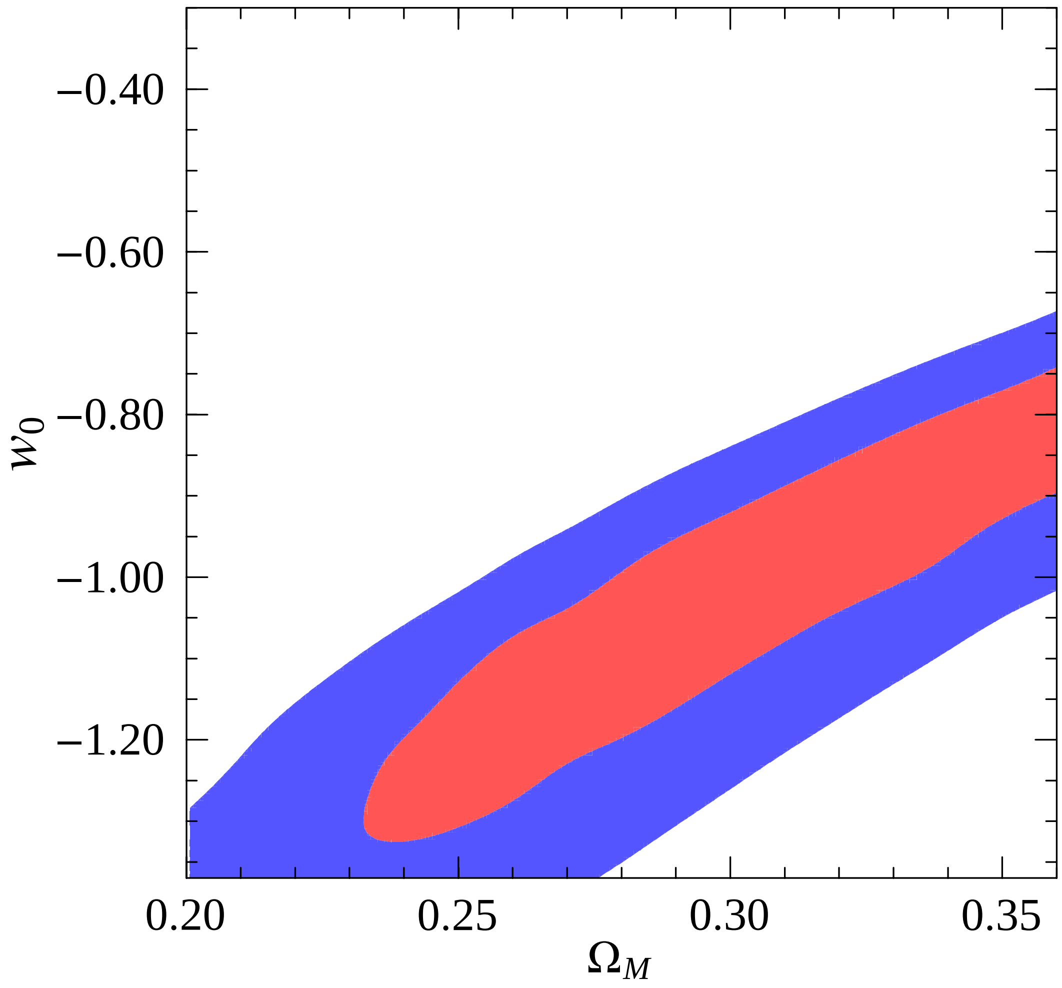
$w_0 - \Omega_M$



−0.40
−0.60
−0.80
−1.00
−1.20
w_0
0.20
0.25
0.30
0.35
Ω_M
BAO
SN
Cluster evolution

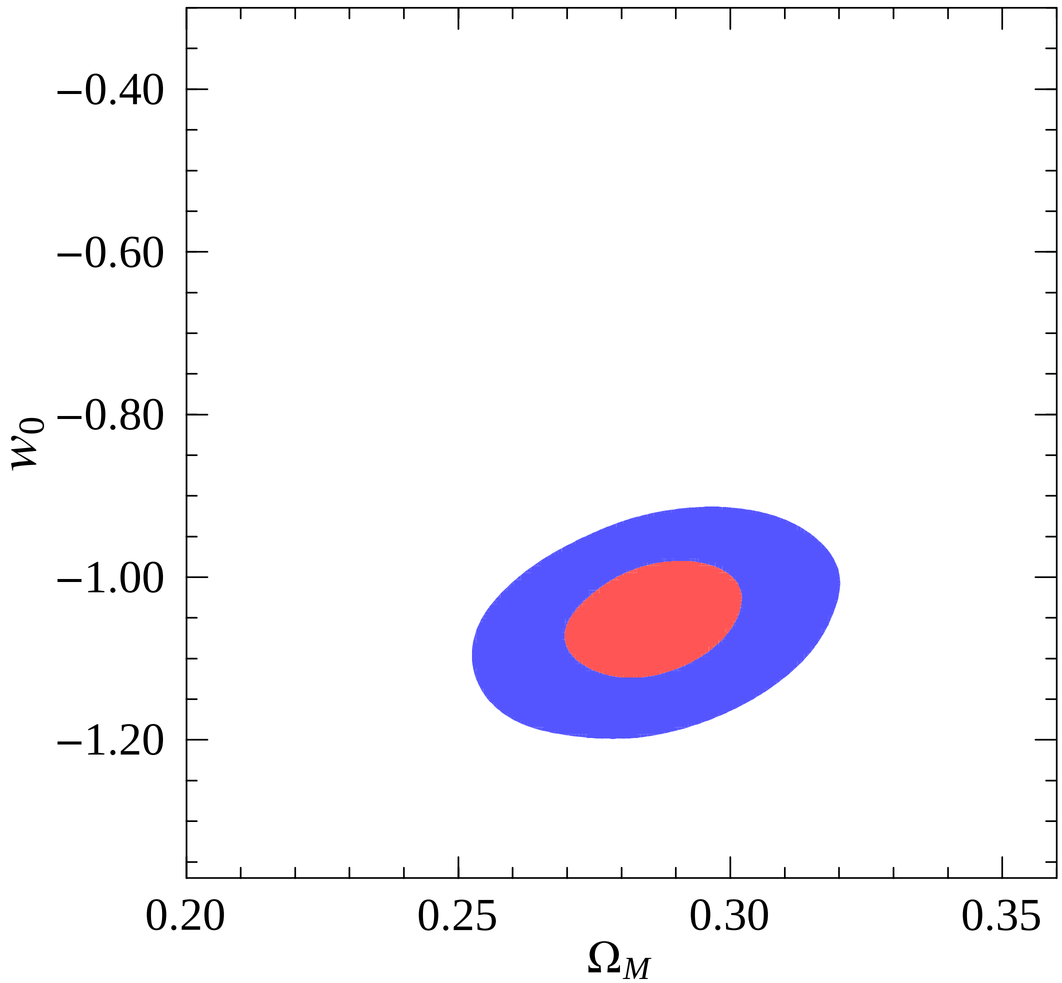
$w_0 - \Omega_M$

CMB + Clusters (evolution and $\sigma_8 \propto \delta_\zeta\,(\Omega_b h^2)^{-1/3}\,(\Omega_M h^2)^{0.563}\,h^{0.693}\,G_0$)



$w_0 - \Omega_M$

CMB + Clusters + BAO + SDSS &2 dF $P(k)$ +SN



$\chi^2_{\mathrm{CMB}} = 1.2\ /\ 2\mathrm{dof}$

$\chi^2_{\mathrm{BAO}} = 0.2\ /\ 1\mathrm{dof}$

$\chi^2_{\sigma_8} = 2.2\ /\ 1\mathrm{dof}$

$\chi^2_{\mathrm{evol}} = 3.1\ /\ 3\mathrm{dof}$

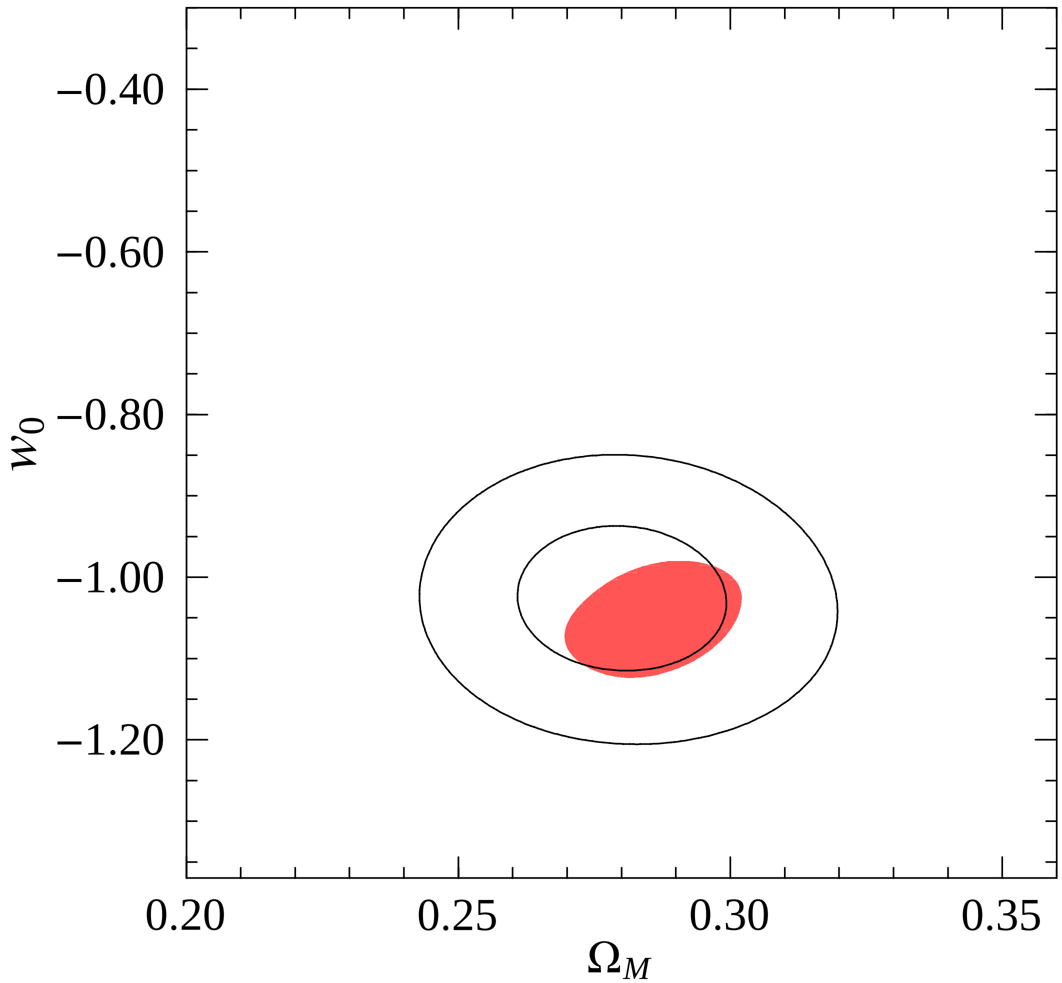
$\chi^2_{P(k)} = 2.1\ /\ 1\mathrm{dof}$

$\chi^2_{SN} = 0.1\ /\ 1\mathrm{dof}$

$\chi^2_{\mathrm{tot}} = 8.9\ /\ 9\mathrm{dof}$

$w_0 - \Omega_M$

CMB "classical" + BAO + SDSS &2 dF $P(k)$ + SN **+ Cluster Data**



$\chi^2_{\mathrm{CMB}} = 1.2$ / 2dof

$\chi^2_{\mathrm{BAO}} = 0.2$ / 1dof

$\chi^2_{\sigma_8} = 2.2$ / 1dof

$\chi^2_{\mathrm{evol}} = 3.1$ / 3dof

$\chi^2_{P(k)} = 2.1$ / 1dof

$\chi^2_{SN} = 0.1$ / 1dof

$\chi^2_{\mathrm{tot}} = 8.9$ / 9dof

$\Delta M/M$ requirements & Role of Con-X

- **Current results:**

  40 clusters, $\Delta w = \pm 0.17 \quad \Longleftrightarrow \quad \Delta M/M \simeq 9\%$

- **Future:**

  400 clusters, $\Delta w = \pm 0.05 \quad \Longleftrightarrow \quad \Delta M/M \simeq 2.5\%$

  4000 clusters, $\Delta w = \pm 0.017 \quad \Longleftrightarrow \quad \Delta M/M \simeq 0.9\%$

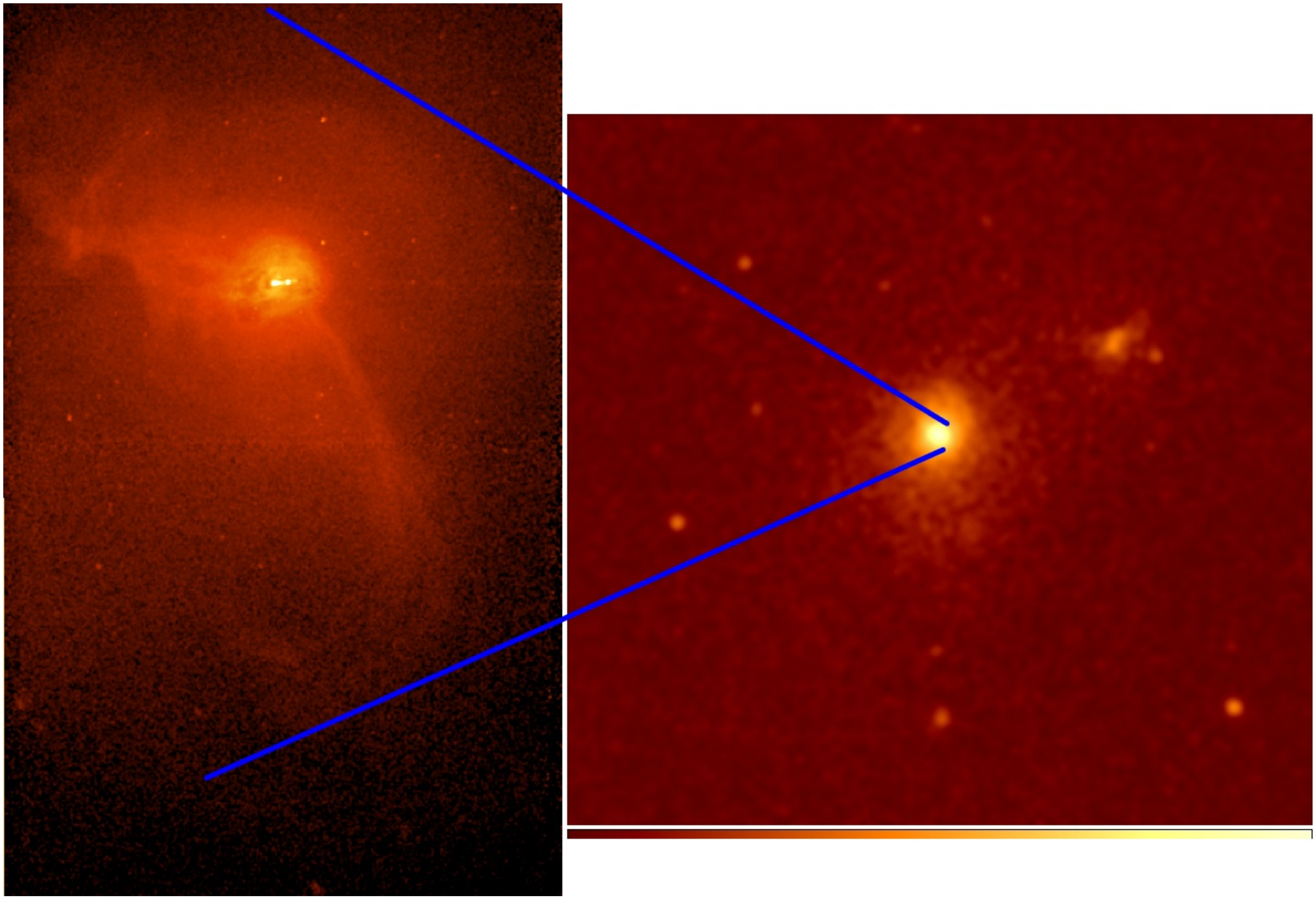
  100000 clusters, $\Delta w < \pm 0.01 \quad \Longleftrightarrow \quad \Delta M/M \lesssim 0.5\%$

- **Via $f_{\rm gas}$ test:**

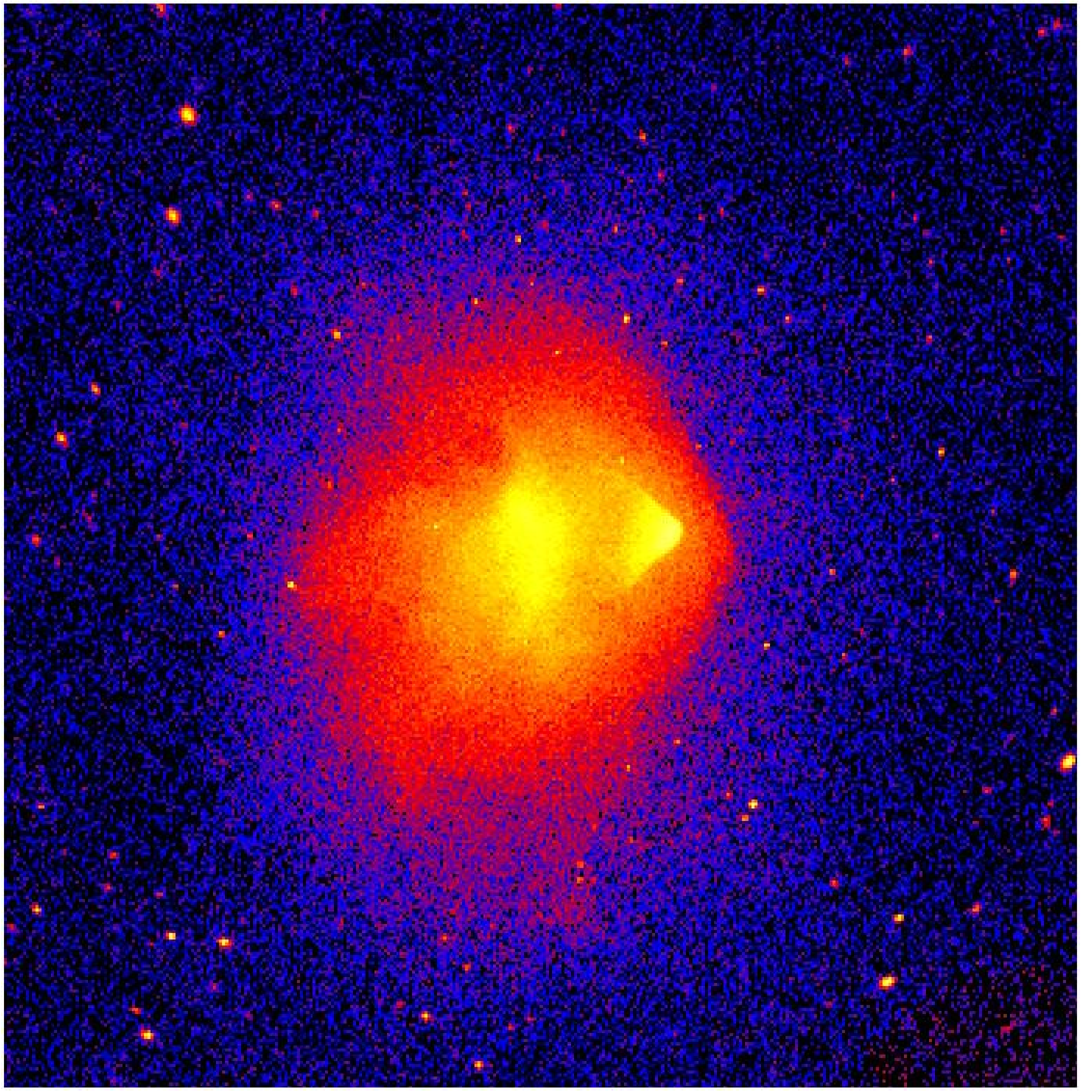
  At $z = 1$: $\Delta M/M = \frac{3}{2}\Delta d/d = 1.6\%$ to ensure $\Delta w = \pm 0.05$

- **Role of Con-X**
  - **provide %-accurate $M_{\rm est}$ in $\sim$ 500 clusters**
  - **Extra info to improve reliability in $M_{\rm est}$**

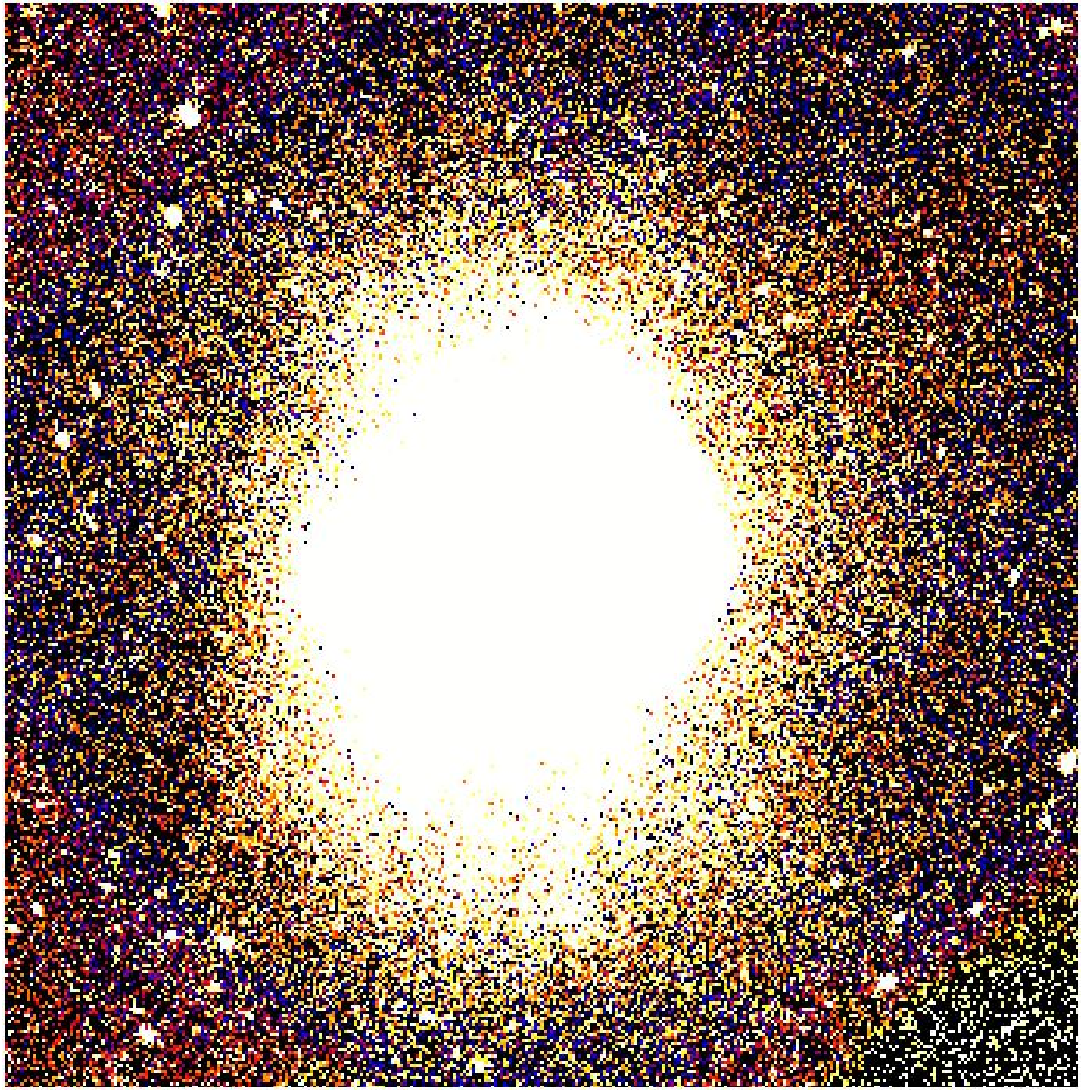
M87



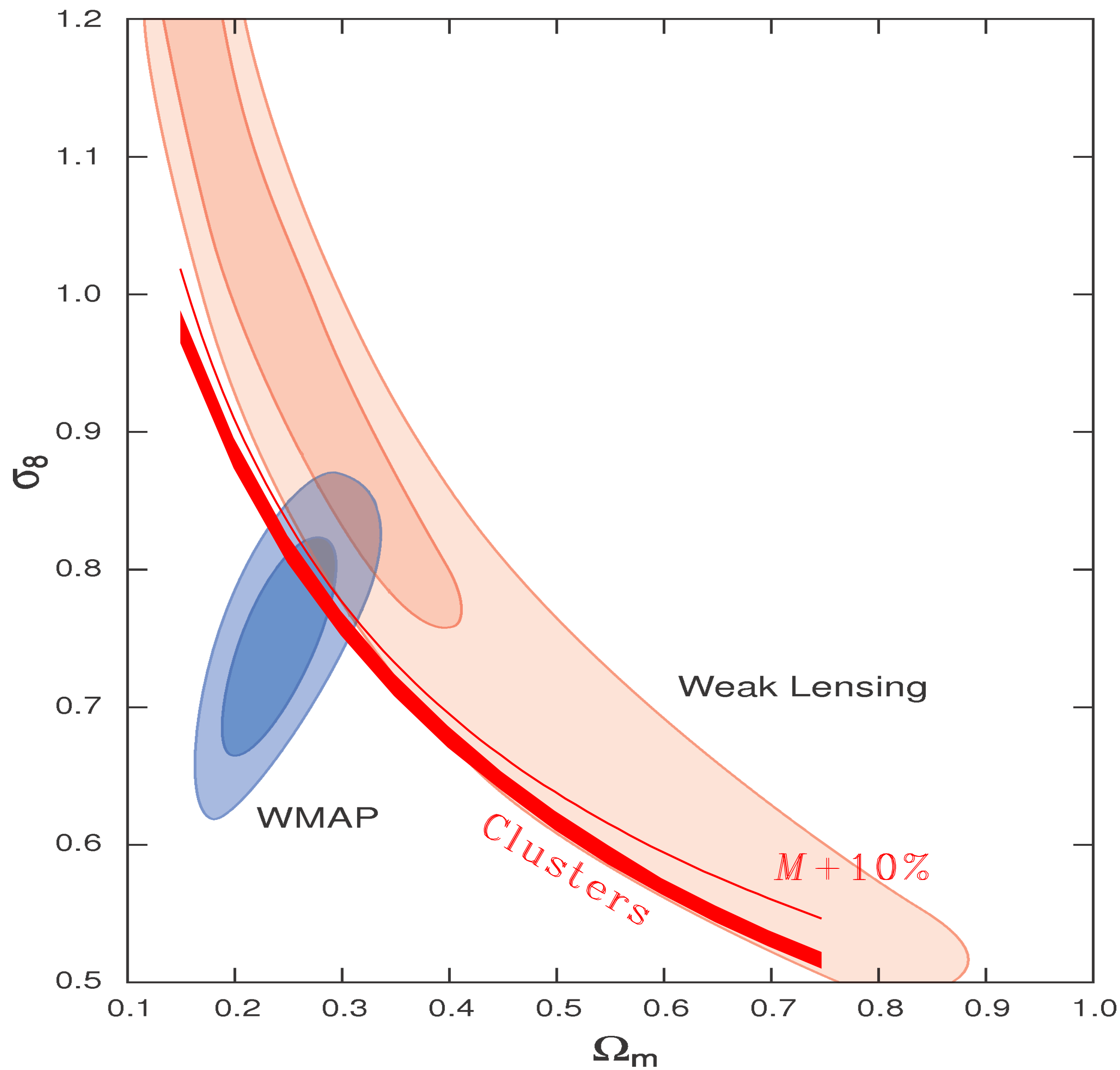
“Bullet Cluster”



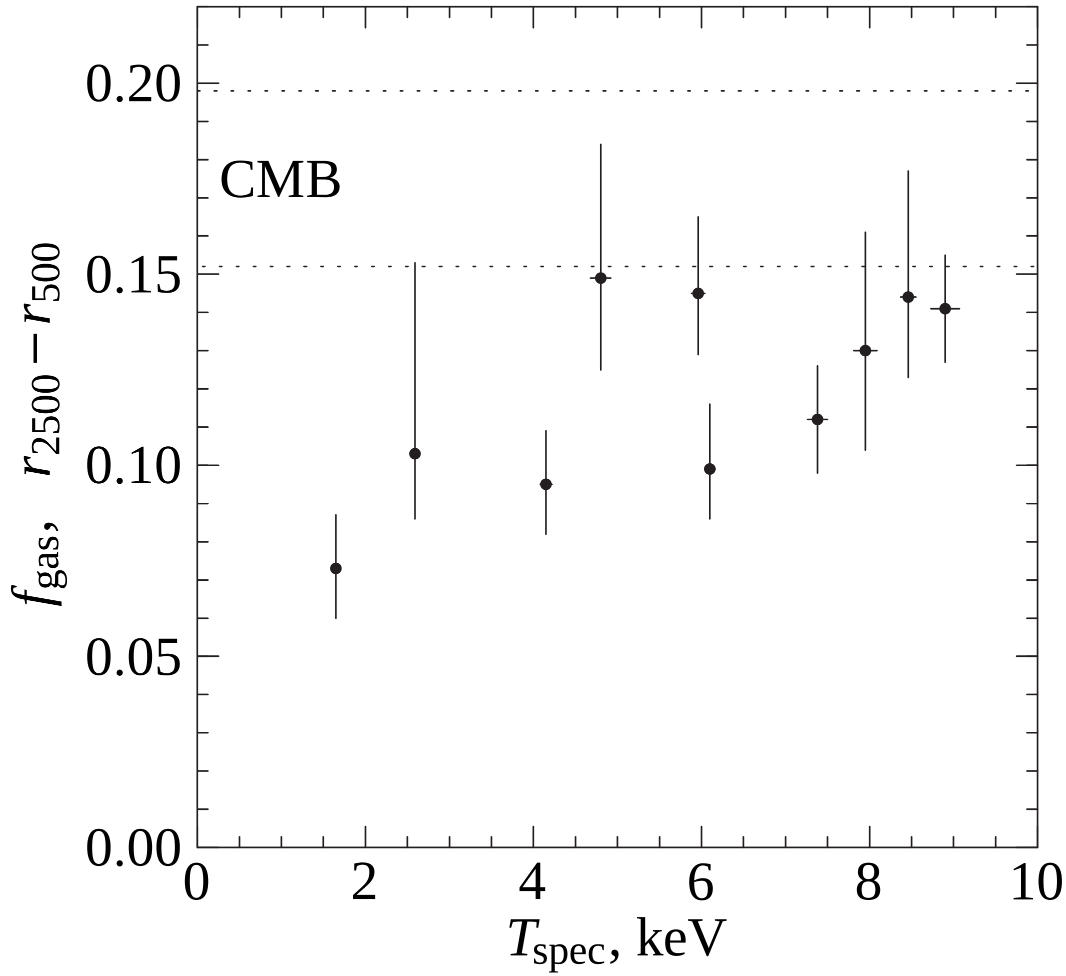
“Bullet Cluster”



What about σ_8?



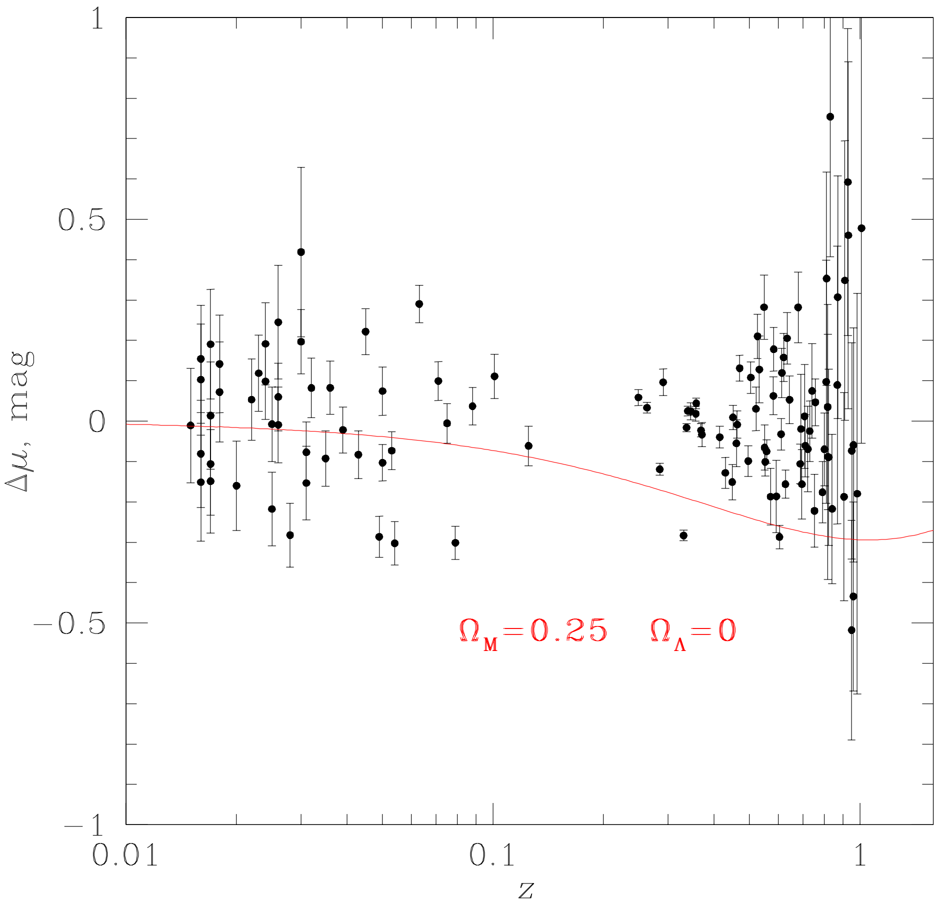
What about f_{gas}?



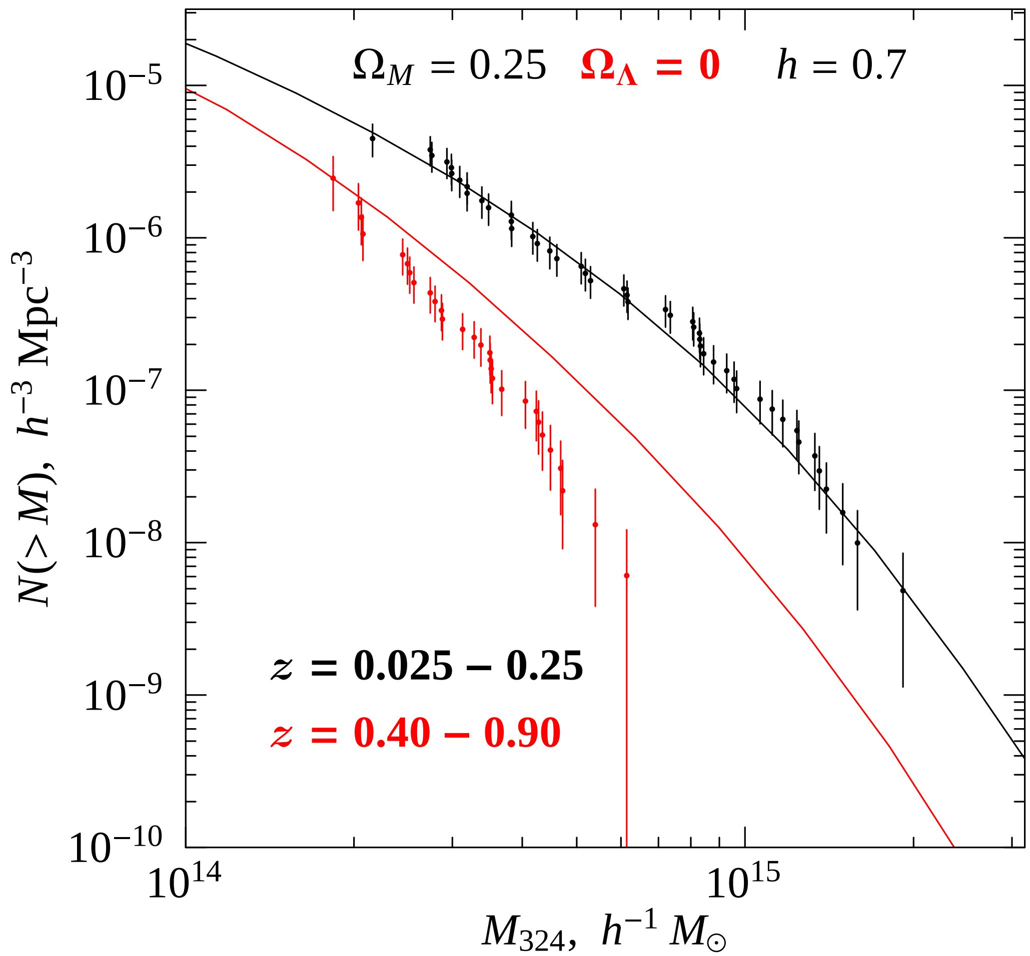
CMB: $\mathbf{\dfrac{\Omega_b}{\Omega_M} = 0.175 \pm 0.015}$

Clusters ($h = 0.68$): $\mathbf{f_{gas} + f_* = (0.146 \pm 0.010)}$ $\boxed{\Delta f = 0.029 \pm 0.018}$

Detection of Dark Energy



SN Ia (SNLS survey)



Clusters (400d = CCCP)